CLAIMS

1. A switching power supply apparatus comprising:

a first switch circuit S1 composed of a parallel connection circuit including a first switch device Q1, a first diode D1, and a first capacitor Cds1;

a second switch circuit S2 composed of a parallel connection circuit including a second switch device Q2, a second diode D2, and a second capacitor Cds2;

an input-side rectifying circuit Da composed of at least one rectifying device for rectifying an AC input voltage;

a third capacitor Ca to which the voltage rectified by the rectifying circuit Da is applied;

a transformer T having a primary winding Lp and a secondary winding Ls;

a rectifying and smoothing circuit RS connected to the secondary winding Ls;

a first inductor Lr connected in series with the primary winding Lp;

a second inductor Li connected so that a voltage of the third capacitor Ca is applied during an on-period for which the first switch circuit S1 conducts;

a third diode Di preventing a reverse current from flowing in the second inductor Li;

a fourth capacitor Ci that is charged by excitation energy stored in the second inductor Li and that is connected so as to apply a voltage to the primary winding Lp during the on-period;

a fifth capacitor Cr forming a closed loop together with the first inductor Lr, the primary winding Lp, and the second switch circuit S2; and

switching control circuits SC1 and SC2 for alternately turning on and off the first and second switch devices with a period of time

during which both switch devices are turned off therebetween.

2. A switching power supply apparatus comprising:

a first switch circuit S1 composed of a parallel connection circuit including a first switch device Q1, a first diode D1, and a first capacitor Cds1;

a second switch circuit S2 composed of a parallel connection circuit including of a second switch device Q2, a second diode D2, and a second capacitor Cds2;

an input-side rectifying circuit Da composed of at least one rectifying device for rectifying an AC input voltage;

a third capacitor Ca to which the voltage rectified by the rectifying circuit Da is applied;

a transformer T having a primary winding Lp and a secondary winding Ls;

a rectifying and smoothing circuit RS connected to the secondary winding Ls;

a first inductor Lr connected in series with the primary winding Lp;

a second inductor Li connected so that a voltage of the third capacitor Ca is applied during an on-period for which the first switch circuit S1 conducts;

a third diode Di preventing a reverse current from flowing in the second inductor Li;

a fourth capacitor Ci that is charged by excitation energy stored in the second inductor Li and that is connected so as to apply a voltage to the primary winding Lp during the on-period;

a fifth capacitor Cr forming, together with the second switch circuit S2, a series circuit connected to both ends of the first switch circuit S1; and

switching control circuits SC1 and SC2 for alternately turning on and off the first and second switch devices with a period of time

during which both switch devices are turned off therebetween.

3. The switching power supply apparatus according to Claim 1 or 2, wherein a second transformer T2 different from the transformer T is provided, the second inductor Li is composed of an input winding of the second transformer T2, and a rectifying circuit Ds2 is provided between an output winding Lo of the second transformer T2 and the rectifying and smoothing circuit RS.

4. The switching power supply apparatus according to Claim 1 or 2, wherein a second transformer T2 different from the transformer T is provided, an input winding Li1 of the second transformer T2 is connected in series with the second inductor Li, and a rectifying circuit Ds2 is provided between an output winding Lo of the second transformer T2 and the rectifying and smoothing circuit RS.

5. The switching power supply apparatus according to Claim 1 or 2, wherein the transformer T has a tertiary winding Lt, and the second inductor Li is connected in series with the tertiary winding Lt.

6. The switching power supply apparatus according to any one of Claims 1 to 5, wherein the third capacitor Ca causes a harmonic component current to flow, and forms a low-pass filter or a portion of the low-pass filter.

7. The switching power supply apparatus according to any one of Claims 1 to 6, wherein a fourth diode Db is connected between the input-side rectifying circuit Da and the fourth capacitor Ci.

8. The switching power supply apparatus according to any one of Claims 1 to 7, wherein one end of the second inductor Li is connected to a node between the first switch circuit S1 and the second switch circuit S2 and the other end is connected to the third diode Di, and both ends of the fourth diode Dc are connected to a node between the second switch circuit S2 and the fifthcapacitor Cr and the node between the first switch circuit S1 and the second switch circuit S2.

9. The switching power supply apparatus according to any one of

Claims 1 to 8, wherein the transformer T includes one or a plurality of drive windings Lb1 and Lb2, and the switching control circuits SC1 and SC2 drive the first switch device Q1 or the second switch device Q2 using a voltage generated in the drive windings Lb1 and Lb2.

10. The switching power supply apparatus according to any one of Claims 1 to 9, wherein delay circuits DL1 and DL2 composed of series circuits including resistors Rg1 and Rg2 and capacitors Cg1 and Cg2 are provided between the drive windings Lb1 and Lb2 and control terminals of the first and second switching devices Q1 and Q2, and the switching control circuits SC1 and SC2 turn on the switch devices Q1 and Q2 with a delay after voltages for turning on the switch devices Q1 and Q2 are generated in the drive windings Lb1 and Lb2, respectively.

11. The switching power supply apparatus according to Claim 10, wherein delay times of the delay circuits DL1 and DL2 are set so that the switch devices Q1 and Q2 are not turned on until the voltages to be applied to both ends of the first and second switch devices Q1 and Q2 are reduced to zero or about zero.

12. The switching power supply apparatus according to any one of Claims 1 to 11, wherein the switching control circuits SC1 and SC2 include switch means connected to control terminals of the switch devices Q1 and Q2, the switch means being turned on a predetermined time after voltages for turning on the switch devices Q1 and Q2 are generated in the drive windings Lb1 and Lb2, thereby turning off the switch devices Q1 and Q2.

13. The switching power supply apparatus according to Claim 12, wherein the switch means is composed of transistors Tr1 and Tr2, and impedance circuits and capacitors Ct1 and Ct2 forming time constant circuits are connected to control terminals of the transistors Tr1 and Tr2, respectively.

14. The switching power supply apparatus according to any one of

Claims 1 to 13, wherein the switching control circuits SC1 and SC2 include time constant circuits TC1 and TC2 for turning off the switch devices Q1 and Q2 a certain time after voltages for turning on the switch devices Q1 and Q2a are generated in the drive windings Lb1 and Lb2.

15. The switching power supply apparatus according to any one of Claims 1 to 14, wherein the transformer T has a leakage inductance, and the leakage inductance is configured as the first inductor Lr.

16. The switching power supply apparatus according to any one of Claims 1 to 15, wherein at least one of the first switch circuit S1 and the second switch circuit S2 is composed of a field-effect transistor.

17. The switching power supply apparatus according to any one of Claims 1 to 16, wherein the switching control circuits SC1 and SC2 control the on-period of the first switch device Q1 so as to stabilize an output voltage obtained from the rectifying and smoothing circuit RS connected to the secondary winding Ls.

18. The switching power supply apparatus according to any one of Claims 1 to 17, wherein the switching control circuits SC1 and SC2 control the on-period of the second switch device Q2 depending upon the voltage across the fourth capacitor Ci.

19. The switching power supply apparatus according to any one of Claims 1 to 18, wherein the switching control circuits SC1 and SC2 suppress the on-period of the second switch device Q2 as the voltage across the fourth capacitor Ci increases, and, transitioning to an intermittent oscillation operation mode in which an oscillation period and a stop period are periodically repeated under a light load or no load, the switching control circuits SC1 and SC2 suppress an increase of the voltage across the fourth capacitor Ci.